RESTRICTED CIRCULATION*

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AGRICULTURAL MEMORANDUM NO 940

COMPARISON OF A WETNESS SENSOR WITH VISUAL OBSERVATIONS

INTRODUCTION

During 1981 hourly observations of leaf wetness were made at four synoptic stations to compare the readings of a sensor against visual assessments of free water in a grass patch. Wind speed, temperature, dew-point, present weather, cloud amount, sunshine and rainfall were also recorded.

LEAF WETNESS SENSOR

The Sensor (figure 1), measuring 30 mm x 80 mm, consists of two interleaved electrodes centered 0.5 mm apart. It is made by etching 0.034 mm thick copper sheet bonded to a substrate of 0.15 mm polyester. The copper is plated with 0.0025 mm of rhodium and the sensor then bonded to a plastic former with a 50 mm radius of curvature. It is deemed wet when its resistance falls below 25 kΩ. For the trial a simple battery powered circuit was built and housed in a small box with two LEDs to indicate the surface condition at the press of a button. Each sensor was clamped to a pole to facilitate height adjustment and the read-out box was housed inside the thermometer screen. Sensors were deployed at Carlisle, Boulmer, Aberporth and Herstmonceux between May and September giving about 150 days of data at each station. They were mounted in the centre of a 1.5 m square patch of grass at each station with an additional sensor mounted in an open position at screen height in the enclosure at Herstmonceux.

THE TRIAL

Grass was allowed to grow for at least the first part of the trial and the sensors kept level with the grass tips. When the growth was uneven the sensor was placed such that it was below about 25% of the tips. Visual observations of leaf wetness were taken in the lower 75% and upper 25% of the canopy. Since there is no definition of leaf wetness it was decided that the grass should be classified as wet if three or more drops of free water were present in the relevant part of the stand within the 1.5 m square. Observations were made every hour throughout the 150 day period. During the experimental period the grass was wet for about half the time giving more periods of surface wetness than would be expected in most years and hence an opportunity to assess different exposures as shown in table 1

FH2B

TABLE 1

	GRASS HEIGHT (CMS)	SENSOR HEIGHT (CMS)	NUMBER OF HOURS
BOULMER	< 10	Similar	528
	10-29	Similar	552
	20-29	Similar	312
	30-39	Similar	504
	≥ 40	Similar	1704
CARLISLE	< 10	Similar	768
	10-15	Similar	840
	16-20	On short grass	2088
ABERPORTH	16-25	16-20	360
	20	10	2354
HERSTMONCEUX	< 10	Similar	360
	10-19	Similar	323
	20	10	153
	20	15	2384
	/	150	3295

ANALYSIS AND RESULTS

Assessment concentrated on the performance in the top $\frac{1}{4}$ as conditions were considered to be akin to those in a cereal canopy. Observations were grouped according to the indicated sensor state and reported state of the grass giving four classes. These classes were then combined to give total number of correct observations and total number of indicated and observed wet observations. Ratios of measured to observed state were then compared for different heights of grass and for the four stations using a method outlined by Snedecor and Cochran (1974). Boulmer results, table 2, showed that performance varied significantly with height of grass but there was no significant difference between groups 10-19 cm and 20-29 cm.

TABLE 2 - GRASS REPORTED WET - BOULMER

	GRASS HEIGHT (cms)	< 10	10-19	20-29	30-39	≥ 40	TOTAL
NUMBER OF HOURS	Sensor Wet	207	276	117	132	537	1269
	Sensor Dry	46	37	11	9	14	117
	Total	253	313	128	141	551	1386

By combining groups 10 cm - 29 cm the 4 stations were compared and showed no significant difference in performance. See Table 3

TABLE 3 - GRASS REPORTED WET - HEIGHT 10-29 cms

		CARLISLE	BOULMER	ABERPORTH	HERSTMONCEUX	TOTAL
NUMBER OF HOURS	Sensor Wet	367	393	181	138	1079
	Sensor Dry	61	48	23	27	159
	Total	428	441	204	165	1238

Results from all four stations for this 10 cm - 29 cm height band are tabulated below to show an overall measure of performance.

TABLE 4 - NUMBER OF HOURS

SENSOR INDICATION OBSERVED STATE	WET WET	WET DRY	DRY WET	DRY DRY	TOTAL	% CORRECT	% WET CORRECT
CARLISLE	367	28	61	384	840	89	92
BOULMER	393	32	48	391	864	91	96
ABERPORTH	181	32	23	124	360	85	104
HERSTMONCEUX	138	1	27	293	293	90	84
TOTAL	1079	93	159	1026	2357	89	95

Most of the differences between indicated and observed state of the grass are for periods with slight showers or before the formation and after the dispersal of dew. Considering the difficulty of making subjective visual observations, especially at night, some differences are inevitable. As the area of the sensor is only 0.1% of the grass patch it is to be expected that the sensor will record less wet occasions than are observed. This problem could be alleviated by having two or more sensors in parallel. As such occasions are of secondary importance in crop epidemiology the performance of the sensors is considered satisfactory.

Of a total of 55 nights when observed leaf wetness could be definately attributed to the formation of dew and the sensors were near their optimum exposure position, they indicated the formation on 53 nights. The sensors also indicated dew formation on two nights when it was not visible on the grass. However onset and dispersal of dew was not necessarily indicated and observed at the same hour and such occasions have been incorporated in table 4.

EXPOSURE

Grass growth was restricted to 20 cms at Aberporth and Herstmonceux with the sensors mounted at 10 cm and 15 cm respectively. With the sensor at 0.5 h there was a 33% overestimate of the time the upper canopy was wet which was reduced to 4% with the sensor at 0.75 h. A second sensor was freely exposed at 1.5 m in the Herstmonceux enclosure and this averaged only 80% of the total duration of leaf wetness in the patch and only 64% for short grass.

At Carlisle the grass was also cut to 20 cm but the sensor was exposed at ground level on an adjacent patch of short grass; it underestimated leaf wetness on the short grass by 13% and overestimated that on the long grass by 6%.

At Boulmer where the grass was left uncut the sensor underestimated the leaf wetness period by 4% for heights between 10 cm and 30 cm. As the canopy grew to over 40 cm and became more open and irregular the sensor overestimated by 39%.

CONCLUSIONS

i. At the end of the test season none of the sensors showed significant signs of deterioration which may be attributed to their low power dissipation for short periods at infrequent intervals (one hour).

ii. As there was no significant difference between the results of the four stations it suggests that the definition of surface wetness used is adequate.

iii. For measurements in grass, or where a grass site is to be used as a control it is recommended that the grass be kept between 10 cm and 20 cms with the sensor mounted at three-quarters of that height.

iv. No systematic differences between measured and observed state of grass could be detected and so it is concluded that the sensor powered in a similar manner is suitable for measurements of leaf wetness but further work is needed to evaluate the performance of the sensor in other crops.

ACKNOWLEDGEMENTS

Thanks are due to Mr R Berry of the Operational Instrumentation branch of the Meteorological Office who designed and built the read-out modules and to the staff of the synoptic stations who carried out the extra duties to such a high standard.

REFERENCES

SNEDECOR, G W, and COCHRAN, W G, 1974. Statistical Methods, pp 240-241

S N WASS
Meteorological Office
Government Buildings
Burghill Road
Westbury-on-Trym
Bristol
BS10 6NJ

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Figure 1a

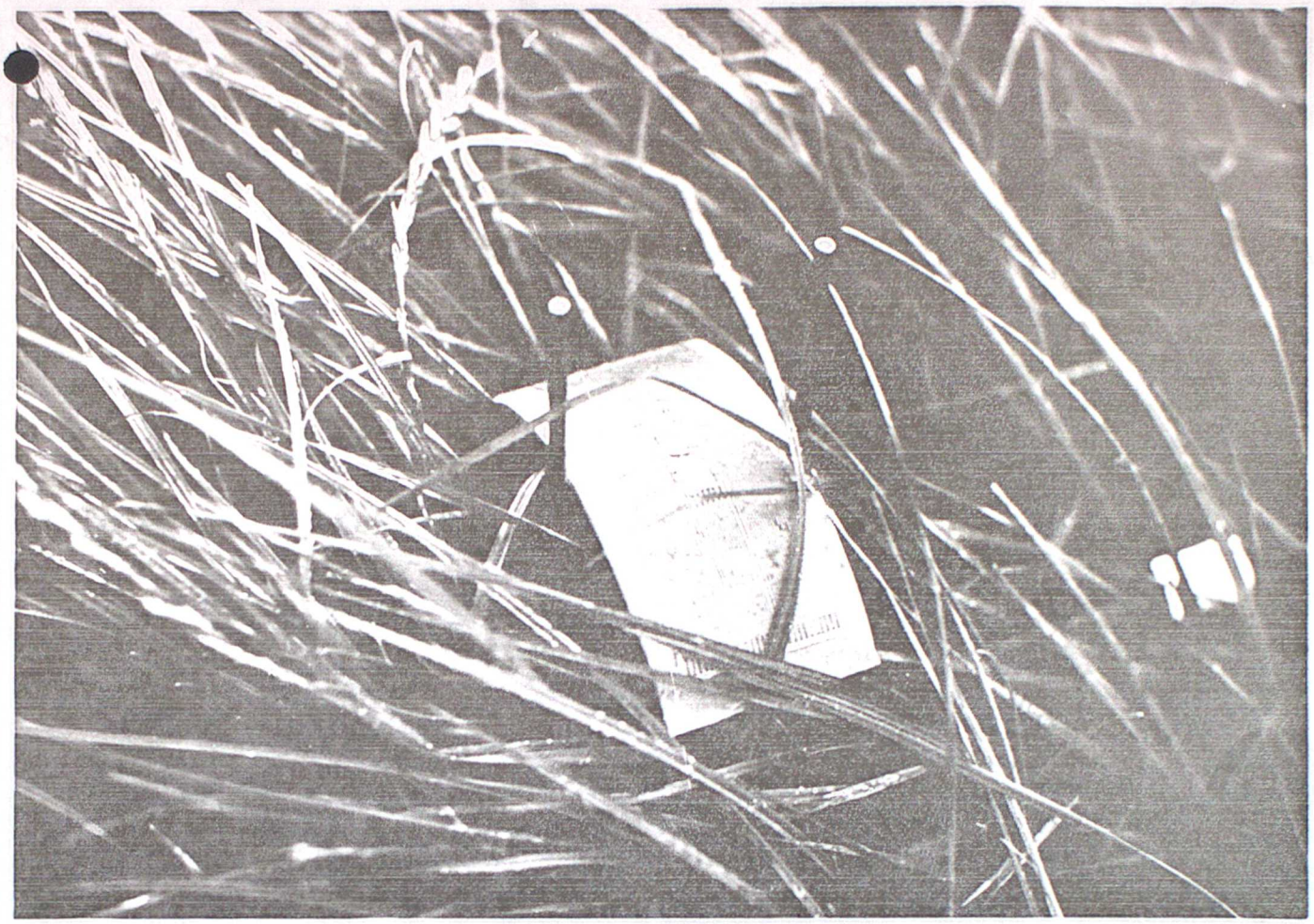
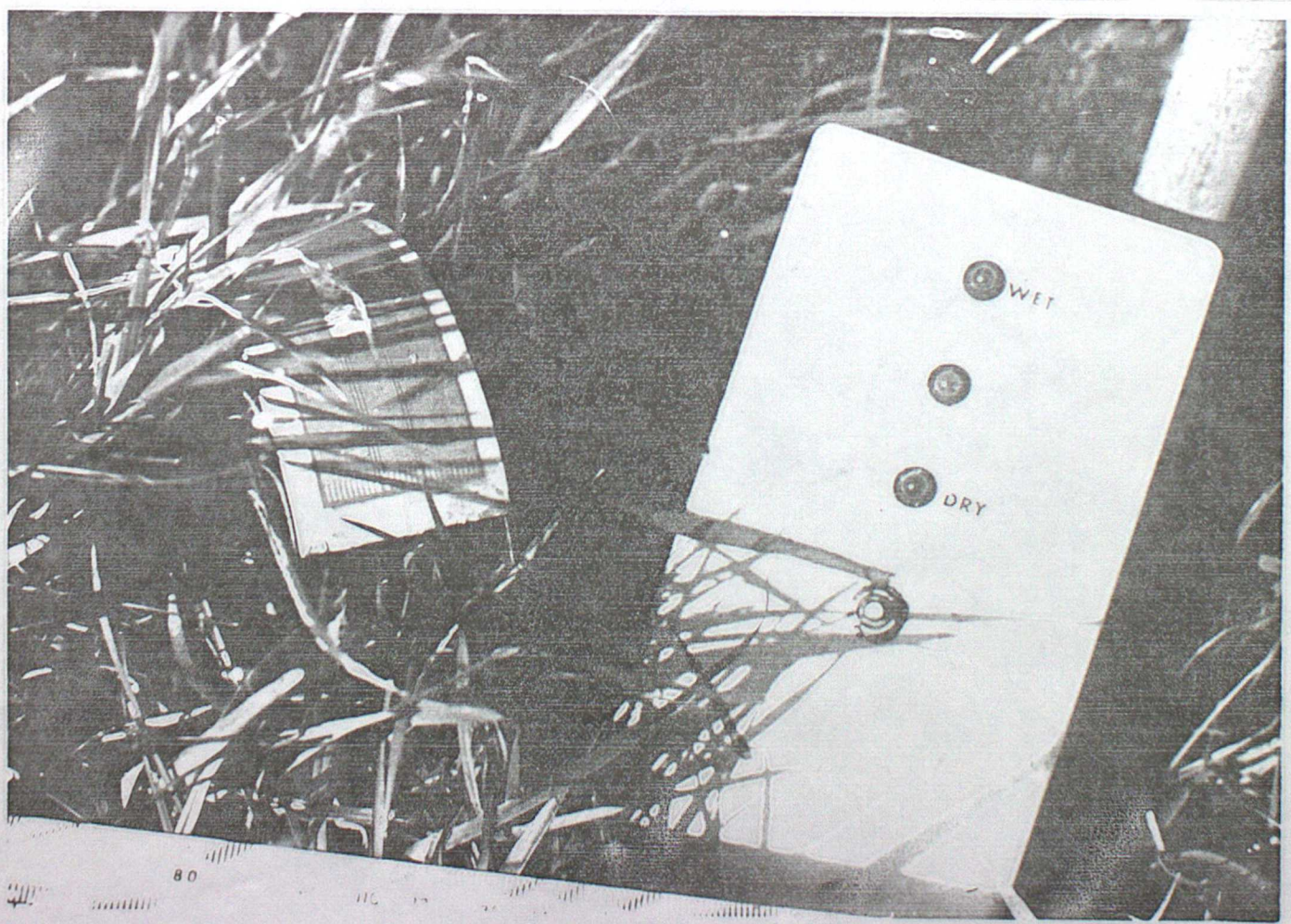


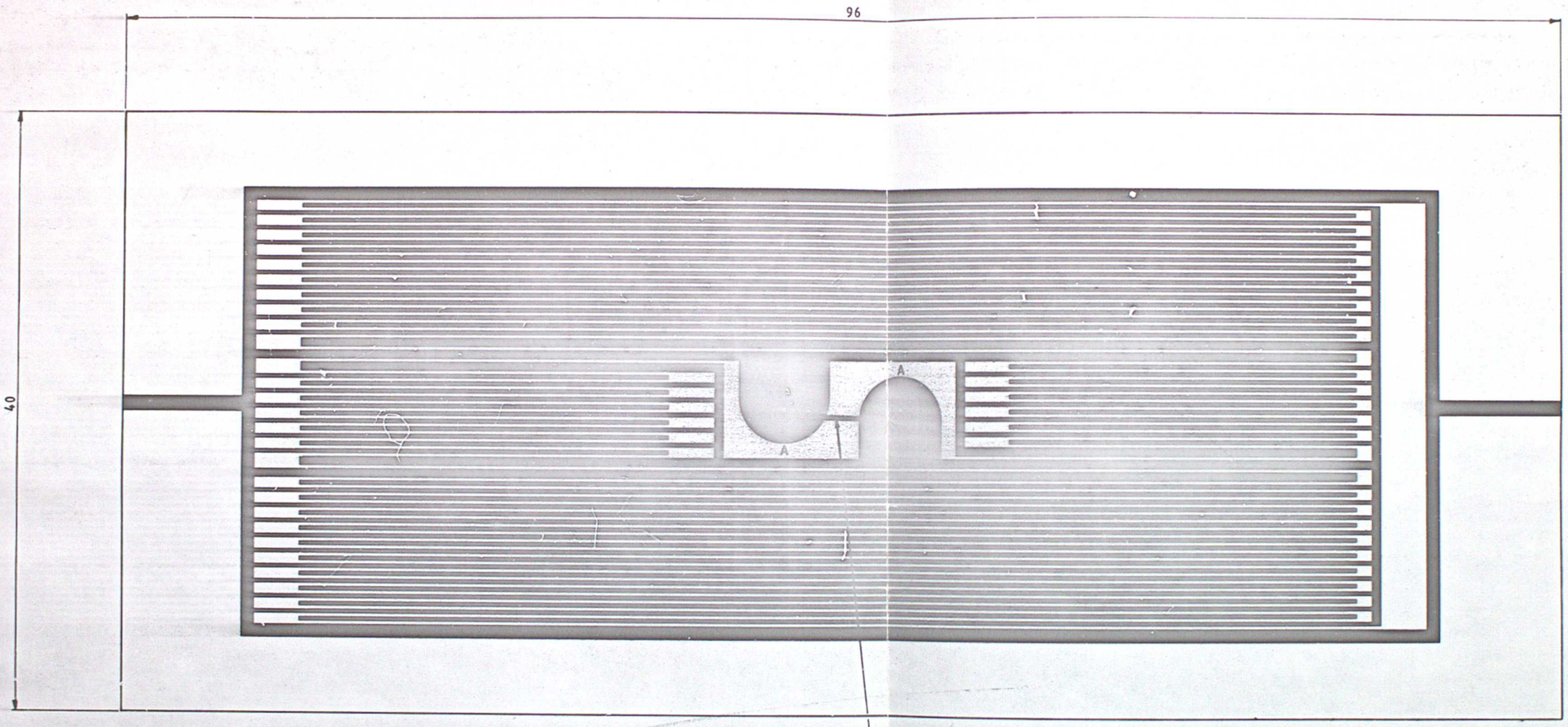
Figure 1b



AO 21623 3rd ANGLE PROJECTION

DO NOT SCALE

REMOVE ALL BURRS



NOTE-
THE LINKING BAR IS TO BE BROKEN AFTER PLATING.

HOLE DATA		
REF	SIZE	Nº OFF
A	⌀1.0	2

1	ISSUE Nº	DIMENSIONS IN mm U.O.S. TOLERANCES UNITS ± 0 · 1 PLACE DEC ± 0 · 1 ANGULAR ± 1°			SCALE 8:1 ASSEMBLED ON DRG. Nº DRAWING LIST Nº	MATERIAL 0·15mm THICK POLYESTER 305 g/m² COPPER CLAD.	FINISH 2·5 µm THICK RHODIUM.
6040	TASK Nº						
—	CHANGE NOTE Nº						
19·8·80	DATE	DRN	PTB	CKD	DMH	USED ON	TASK 6040
—	MODIFIED BY	DATE	19·8·80	DATE	APP. DATE		METEOROLOGICAL OFFICE

SURFACE WETNESS PROBE P.C.– DRILLING & MACHINING.

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